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Development of the SAMEX Vector Magnetograph at the Marshall Space Flight Center

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Abstract

A breadboard design to prove the operational feasibility of SAMEX Vector Magnetograph is being developed at Marshall Space Flight Center (MSFC). Although the breadboard design will not include all of the elements of the original design concept, critical elements such as the large detector array and the high resolution polarimeter will be important parts of the breadboard design to study the data analysis and compression techniques that will be needed in a SAMEX instrument, to study the calibration techniques for systemmatic errors in the polarimeter, and to obtain high resolution vector magnetograms during the next solar maximum. Although the SAMEX polarimeter is not optimum for a groundbased patrol instrument, the design concept can be confirmed with groundbased measurements and direct comparisons with the existing MSFC vector magnetograph. The extension of the scientific objectives for this breadboard design is possible if a tunable filter can be acquired.

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Scientific Objectives of the SAMEX Vector Magnetograph

+ To observe the formation and configuration of non–potential fields in photospheric active regions
+ To quantify the non–potential characteristics of these fields (e.g., angular shear, electric currents) in flaring and non–flaring regions
+ To quantify the free magnetic energy and the force–free nature of active–region fields as they develop and evolve
+ To determine what factors lead to the destabilization of the fields and the eruption of flares

Instrumental requirements to meet Scientific Objectives

+ Temporal resolution of a few minutes
+ Field of View to contain a typical active region
+ Spatial resolution of at least 0.5″
+ Polarization resolution of at least 10E−4
+ Spectral resolution of approximately 1/8 Angstrom

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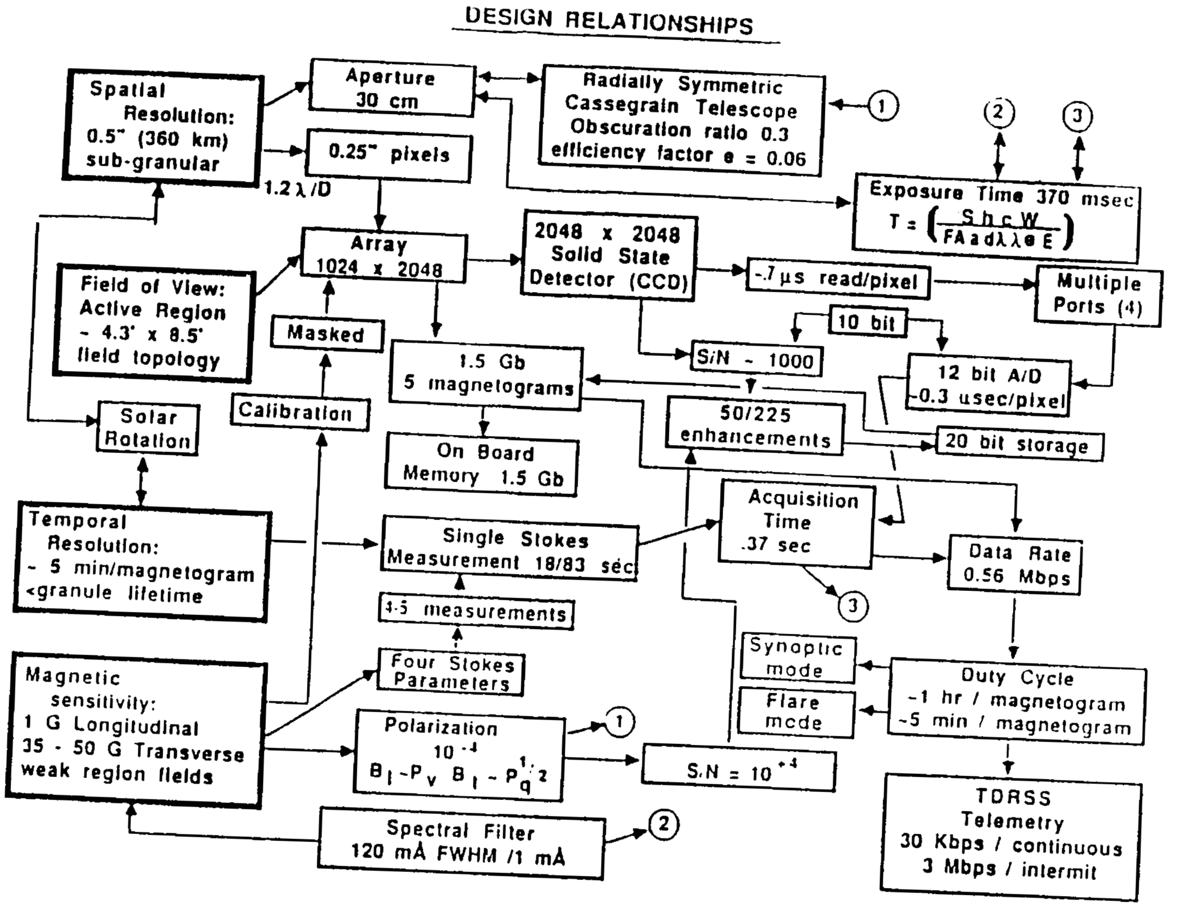


Figure 11. The overall interrelations of the SAMEX magnetograph requirements. This diagram shows how the design specifications for spatial resolution, field of view, temporal resolution, and magnetic sensitivity are interrelated with each other and produce requirements on the magnetograph instrument, onboard computers, and spacecraft systems. To satisfy most of these requirements in an optimum sense requires many different trade-offs. The details of these relationships are described in the text.

Reasons for selecting a rotating polarizer as the active element in the polarimeter

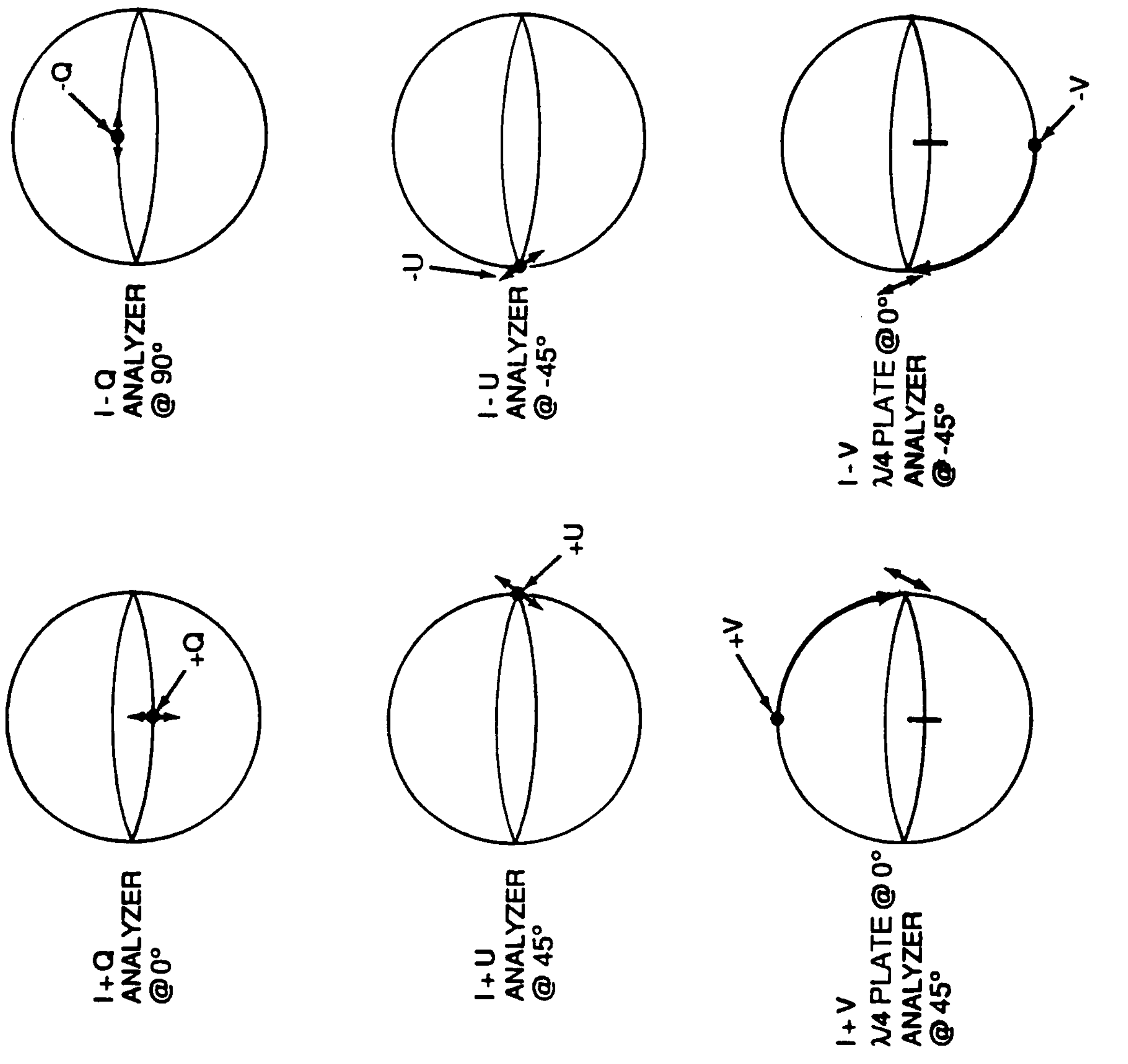
+ The transverse field (linear polarization) is more difficult to measure (the longitudinal field is related to the circular polarization), therefore the polarimeter should be optimized for the linear polarization measurement.

+ The removal of retarders in the linear polarization measurement eliminates circular crosstalk (which is the stronger signal) and improves the polarization resolution.

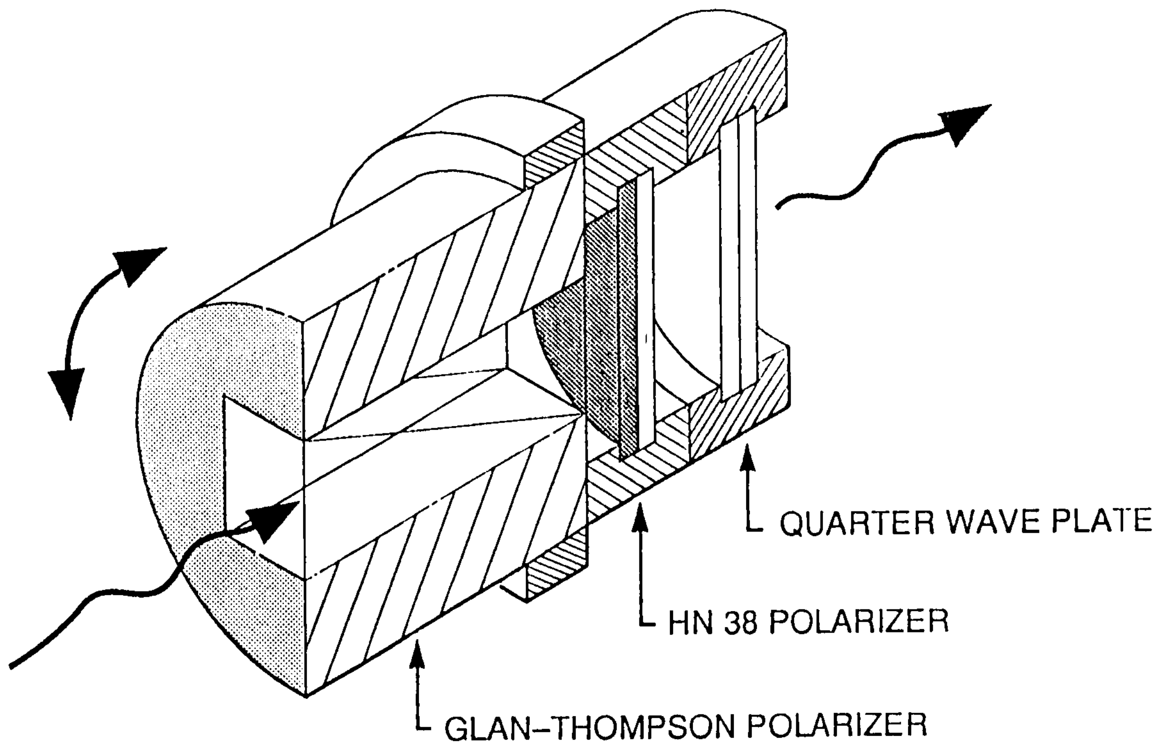
+ Using redundant measurements, systemmatic errors in the remaining retarders (the rotating quarterwave plate following the analyzer and the fixed quarterwave used to measure the circular polarization) can be corrected for.

Table 1. Sequence of measurements using a rotating polarimeter and fixed quarterwave plate

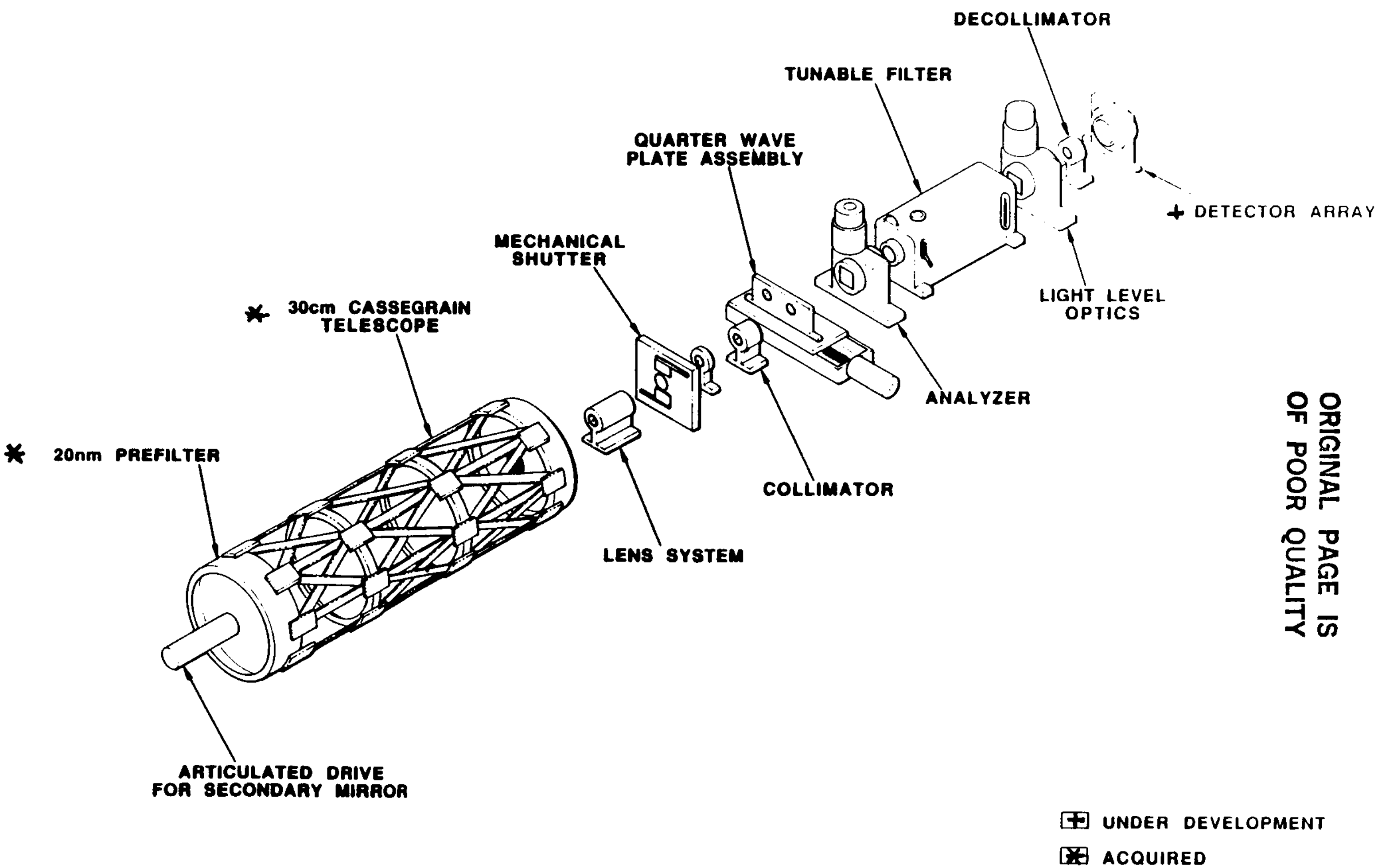
Angle of polarizer	Intensity measurement	
	Wave plate out	Wave plate in
0°	$I + Q$	$I + Q$
45°	$I + U$	$I + V$
90°	$I - Q$	$I - Q$
135°	$I - U$	$I - V$
180°	$I + Q$	$I + Q$
225°	$I + U$	$I + V$
270°	$I - Q$	$I - Q$
315°	$I - U$	$I - V$


I+Q
ANALYZER
@0°
+Q
I-Q
ANALYZER
@ 90°
-Q
I+U
ANALYZER
@ 45°
+U
I-U
ANALYZER
@ -45°
-U
I+V
λ/4 PLATE @ 0°
ANALYZER
@ 45°
+V
I-V
λ/4 PLATE @ 0°
ANALYZER
@ -45°
-V

Rotating Analyzer



THE SYSTEM CONFIGURATION FOR THE SOLAR VECTOR MAGNETOGRAPH



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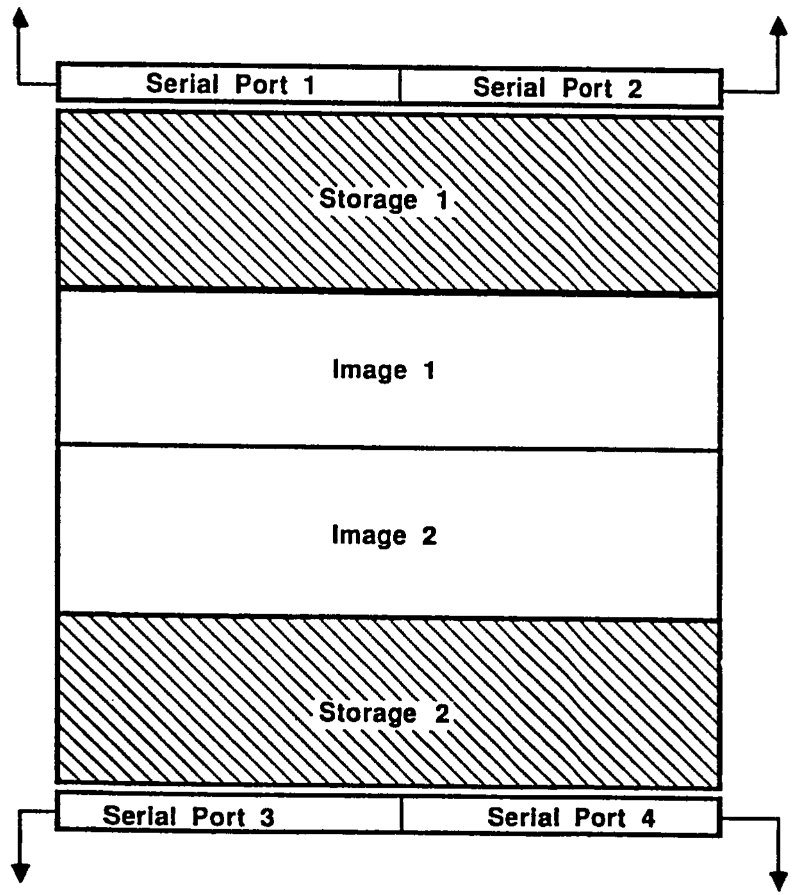
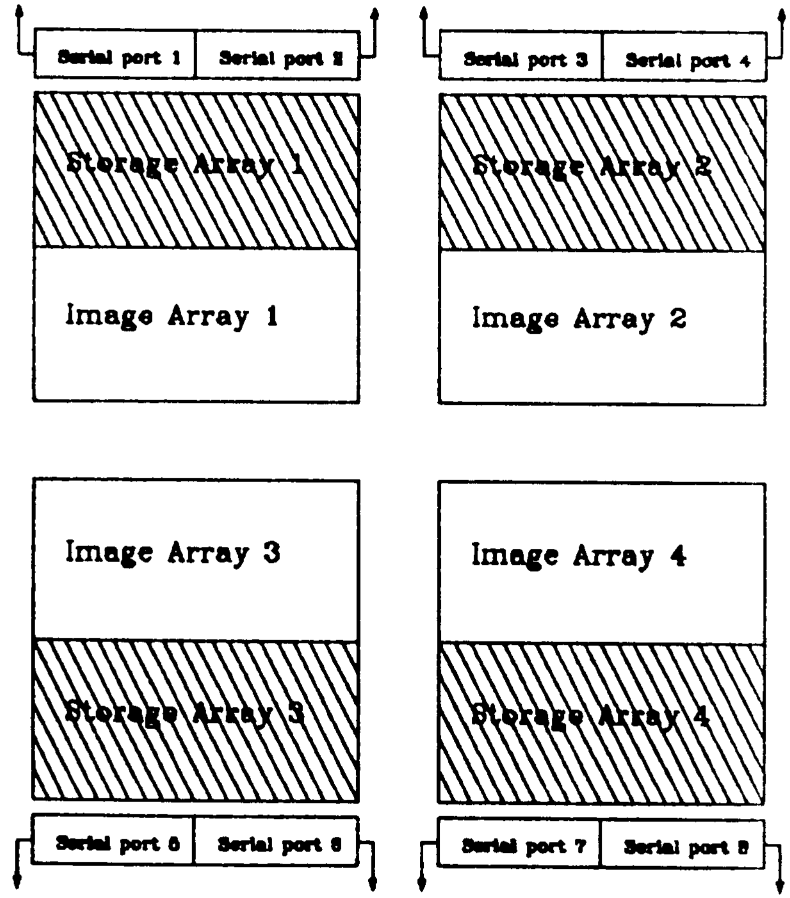
	Proposed SAMEX detector system	Preliminary breadboard design
Manufacturer:	Tektronixs	Thomson
Array size:	2048 x 2048	4 (1024 x 1024)
Pixel size:	27 microns	19 microns
Well size:	750K electrons	250K electrons
Quantum Efficiency:	45 %	45 %
Proposed readout rate	4.8 Megapixels/sec.	9.6 Megapixels/sec.

There are 4 serial ports on each Thomson CCD. The camera controller will be designed for flexibility so that it can handle CCD's developed in the future. The 2 port design (8 total) is required to match the smaller well size of the Thomson sensor with the S/N and time resolution requirements that satisfy the scientific objectives.

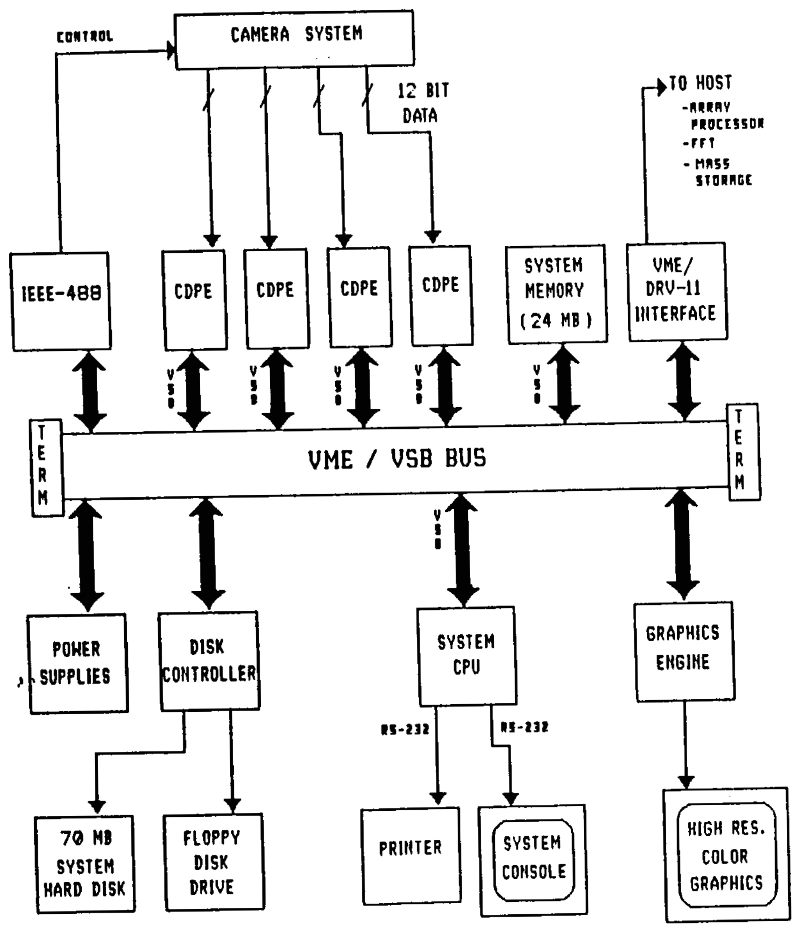
Proposed SAMEX detector system



Preliminary breadboard design



Preliminary Design of the Solar Vector Magnetograph Data Acquisition System



Preliminary design produced by Ralph Kimball of Echotek Inc.